Thermal Conductivity of Amorphous Carbon Thin Films

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Solid forms of carbon provide the largest (diamond) and nearly the smallest (amorphous C60 compacts) thermal conductivities known for fully dense materials at room temperature, suggesting that the atomic-scale microstructure of carbon thin films could lead to both high and low conductivity materials for thermal management applications. We have studied the thermal conductivities of a-C:H and a-C films deposited by a variety of methods selected to span the range from low, polymer-like behavior to the relatively high thermal conductivities of "amorphous diamond". The through-thickness thermal conductivities are measured in the temperature range 80-400 K using the 3-omega method for thin films. We find that the density dependence of the data is in surprisingly good agreement with a simple effective medium calculation that models the density deficits relative to diamond as atomic-scale voids. The thermal conductivity of the extrapolated fully dense matrix is also in good agreement with the predicted minimum thermal conductivity for amorphous diamond.